PUBLISHING COMMITTEE.

S. H. Scudder,          Edward Burgess,
S. L. Abbot, M.D.,      F. W. Putnam,
                    Alpheus Hyatt.
Prof. E. S. Morse described the differences he has found between the shells of the Kjoekenmoeddings of New England and those of the same species of molluscs living at the present day. Allied species are all found to vary in the same way, and farther, comparing the Japanese shell-heaps with those of New England, an exactly parallel state of things is found. Professor Morse illustrated these points by specimens and tables of measurements.

Professor Hyatt observed that these changes of form could hardly be ascribed to the action of natural selection. Climatic influences seemed to be the only possible explanation.

Mr. F. W. Putnam remarked that he had received specimens of Buccinum diversum from ancient mounds very much larger than the present forms of the same species.

The following paper was read:

ON SOME DIFFERENCES IN THE MOUTH STRUCTURE OF TADPOLES OF THE ANOUROUS BATRACHIANS FOUND IN MILTON, MASS.

BY MARY H. HINCKLEY.

The following observations on some of the differences in the external structure of the mouth of our tadpoles, were made at Milton, Mass. With the exception of Scaphiopus solitarius Holbr., the burrowing frog, the list includes all the species commonly found in Massachusetts.

Observing the mouth of these tadpoles, it will be seen that they are divided by differences in this organ into three groups; that each one of these groups includes lesser differences of varying importance; and that, corresponding to these larval groups, differences of habit are found in the adult forms.

Fig. 1 of Plate 5 represents the head of a full grown tadpole of Rana catesbeiana, showing the position and relative size of the mouth. Between the flexible upper and under lip (fig. 2. a, b,) is a pair of hard, beak-like jaws, the margins of which are colored to a greater or less width with dark brown or
black, and edged with numerous sharp, pointed teeth. The upper jaw (fig. 2. c.) is larger and projects beyond the lower jaw (fig. 2. d.), so that when the mouth is closed the latter is not seen at all. Overlapped by the upper lip and running parallel with it, at each side the upper jaw, are two fleshy folds the free edge of which is fringed with what appears by the aid of a magnifying glass a row of narrow, rigid, black, closely-set tines or teeth, uneven in length, and sometimes in width, with a tendency to hook inwards. With occasional exceptions in the tadpoles of Rana catesbeiana, the edge of the upper lip, in all the species to be described, is itself fringed in like manner. Crossing the pendent under lip, are three folds (fig. 2. e.) reversed as to the position of the fringed edge from those under the upper lip. The margin of the under lip forms a border which extends up to, and joins, the upper lip. Excepting in the tadpoles of Bufo americanus, B. fowleri and Hylodes pickeringii, this border (fig. 2. f.) is entirely edged with a row of papillae, more or less papillae being also found within it each side of the mouth. The papillae vary in color, size, number and position.

One of the purposes of this papillose edge is, apparently, to test the nature of the objects the tadpole comes in contact with,¹ and the stiff fringe along the edge of the lips and folds, serves to collect and hold their food. These fringed folds are perfectly free, excepting at their base; those on the under lip are usually held at an angle from the lip; but are capable of being laid back as is shown when the tadpole wishes to reject any substance held by the fringe. The upper jaw is stationary, but both upper and under lips are employed the greater part of the time in collecting and conveying food to the jaws. Although one might suppose that nothing eatable comes amiss to a tadpole, it may be observed that much is rejected after it has been tried between the jaws, and, apparently lest this may be entangled in the fringes, it is expelled with considerable force from the corners of the mouth.

The result of my observations goes to prove that the food of the different tadpoles, after they leave the gelatinous substance surrounding the eggs which they commonly feed upon first, con-

tinues to be, by choice, animal rather than vegetable. On the death of one of their number, and even before this event has really taken place, the companions proceed at once to devour all but the bony skeleton; and indeed the best means of securing the skeleton in its most perfect condition is to leave the preparation of it to the living tadpoles.

The difference which first arrests the attention in the mouth is the form given it by the lips. This character divides the tadpoles under consideration into three groups. The first contains two tadpoles which agree in having a broad, even, upper lip fringed at the edge. The margin of the under lip forms a border which extends up to and laps on the upper lip; the edge of the border doubles inward at both corners of the mouth. Excepting the wide space at the edge of the under lip which is fringed, the border terminates in a papillose edge; the space in the border occupied by the fringe is deeper by the width of the fringe than the adjacent part occupied by papillae (fig. 3). This form of mouth is found in the tadpoles of the toads Bufo americanus Leconte, and B. fowleri Putnam.

The second group also contains two tadpoles which agree in having a broad, fringed upper lip gradually lengthened from the middle into two deep curves. The border instead of doubling inward at the corners of the mouth is continuous to the union with the upper lip. The papillose edge of the border overlaps the upper lip about one-third its entire length on each side. The papillae are small and those within the border are closely set near the edge (fig. 4). The tadpoles of this group develop into frogs having the toes expanded into adhesive discs, Hyla versicolor Leconte, and Hylodes pickeringii Holbrook.

In the third division we have five tadpoles which agree in having a short and narrower upper lip than the others have shown. The margin of the under lip terminates in a papillose edge which is doubled inward at each corner of the mouth and laps on the upper lip to which it extends (fig. 7). The tadpoles of this group are those of the frogs Rana silvatica Leconte, R. catesbeiana Shaw, R. fontinalis Leconte, R. halecina Kalm, and R. palustris Leconte.

For convenience of comparison the figures intended to represent the mouths are not given with reference to relative size.
They show this feature at the same stage of growth, that is, when the tadpole has reached the limit of its size. After the parts of the mouth are developed I have observed no change of form in the folds or papillae.

In the tadpoles of Bufo americanus and B. fowleri one finds the least variability of mouth structure. Both have one fringed fold under the upper lip with a short gap above the upper jaw, and two fringed folds on the under lip with a space of fringe set in the edge of the border midway the lip. Some variability exists in the number of papillae at the edge of the lip and also in the number and exact position of those within the border. The mouth of B. fowleri is distinguished from that of B. americanus (fig. 3) by a greater delicacy of texture, shown especially in the border papillae, which instead of being firm and rounded are soft and flat. The tadpoles agree in size and general form but differ in color.

In the adult forms we find externally some difference in structure but more in color, voice and habit. In Milton, B. americanus appears earlier in the spring, braving a lower temperature than B. fowleri. Usually the short period of egg-laying is over, the toads are silent and have dispersed to the land before B. fowleri is heard; the latter remains longer at the water, the period of egg-laying extending into July. The bleat of B. fowleri with its far reaching metallic ring is usually heard after sunset. I have seen the latter give voice on the land, while the trill of B. americanus, heard at all times of day and night during the mating season, I have only seen given in the water.

The tadpoles of the Ranidae separate into two groups one having three and the other four fringed folds on the under lip. Those of R. silvatica, which represent the latter group, have a mouth (fig. 6) delicate in texture, with three fringed folds under the upper lip each side the upper jaw, decreasing in length towards the under lip. The fringe or teeth on the shortest fold are sometimes wanting. The edge of the upper lip is occasionally scalloped, and the fringed folds on the under lip which are variable in length are usually wavy in such cases; that next the under mandible or jaw is divided midway its length, and now and then the fold below it is partially separated at the same point. Occa-
sionally one or more short fringed folds are inserted within the border at the sides of the under lip. The under lip is longer than that of Rana catesbeiana, R. fontinalis, R. palustris, and R. halecina, which form the second group and agree in having three fringed folds, variable in length, on the under lip, with a division in that next the under jaw.

In R. catesbeiana (fig. 7) the edge of the upper lip is either entirely fringed or furnished partially with papillae and fringe; the papillose portion is shorter by the width of the fringe than the remainder of the lip. Under the upper lip are two fringed folds each side the upper jaw; the lower one is short and occasionally wanting in the few teeth that fringe the edge. The mouth is spotted and papillae usually marked more or less with black.

The larvae of R. fontinalis, R. palustris, and R. halecina have one fringed fold under the upper lip at each side the upper jaw, with some variability in its presence in the two last-named species. Tadpoles of R. fontinalis (fig. 8) have the papillae, folds and floor of the mouth conspicuously marked with black. R. palustris (fig. 9), in common with R. catesbeiana and R. fontinalis, has a mouth of firmer texture than R. halecina. The latter, both in the upper lip and fringed folds, shows frequently an undulated edge. The under jaw of R. palustris and R. halecina has a wide margin of color.

The mouths of the tadpoles of the Ranidae here described, have, as a rule, papillae varying in number even in the same species, within the border at the sides of the mouth; these papillae are placed as if in continuation of the fringed folds now present in the mouth. In larvae of R. halecina it is not unusual to find one or two of the fringed folds on the under lip continued parallel with each other and the contour of the lip, taking the place of the papillae at other times found in the same space. One tadpole of this species in my collection has from one to three teeth of the fringe attached to two papillae within the border. In all the species of the Ranidae found here, short fringed sections are sometimes inserted in place of papillae. The mouths of greatest delicacy are subject to most variability in this respect.
That the four tadpoles having three fringed folds on the under lip are more nearly related to each other than to R. silvatica seems evident, but to arrive at a conclusion as to the place they really hold is scarcely possible here. Now taking the adult forms, we find in R. catesbeiana, R. fontinalis, R. palustris, and R. helecina, four water frogs, of which R. catesbeiana is the most aquatic in habit, R. fontinalis stands next and R. palustris and R. helecina are the least so. In R. silvatica we have a land frog widely separated from the other frogs in habit. It is only during the short period of egg-laying that these frogs remain at the water and as soon as that is over they disperse to the land. In this locality R. silvatica is commonly seen during the summer in the woods among the brown fallen leaves, especially in groves of oaks and pines. R. silvatica is smaller in size, more delicate in structure and endures a lower temperature than either of the other species, appearing first in the spring and disappearing last in the autumn. Separating these frogs according to their habits, we have one land frog and a group of four water frogs, a division which corresponds with that expressed by the mouth structure of the tadpoles.

In the Hylidae we have two tadpoles, Hyla versicolor, our common tree frog, and Hyloides pickeringii, the small, brown, peeping frog, whose voice is such a feature here in early spring. The difference between these mouths is in the fringed folds on the under lip. The tadpoles agree in having under the upper lip one fringed fold running parallel with the curves of the lip, with a gap above the upper jaw. On the under lip of H. versicolor (fig. 4) are three fringed folds which frequently present a wavy line; the middle fold is sometimes divided midway its length. The edge of the upper lip is occasionally scalloped or extended so as to form a small point between the curtains of the lip.

With the tadpoles of H. pickeringii (fig. 5) there are but two fringed folds on the under lip with a short space of fringe inserted at the edge of the border; this section of fringe usually occurs midway the under lip, but it is not constant in its position, exact number of teeth, or presence; occasionally it may be found a little to the right or left of the middle of the mouth, and now and then it does not appear at all.
fringe occurs the papillae are wanting, and those mouths in which fringe does not appear here at all present an unbroken line of papillae along the edge of the border. This fringe is placed in a position similar to that in the tadpoles of B. americanus and B. fowleri, but with the latter it occupies a much wider space. With H. pickeringii there is a tendency to carry the margin of the under lip turned upwards towards the mouth as is seen in the Bufonidae.

Comparing the adult forms we find they differ markedly in habit. H. versicolor spends no more time at the water than is necessary for the purposes of egg-laying and at once returns to the trees, while H. pickeringii becomes aquatic for several weeks in the spring, after which it seeks the land and low bushes, its presence in trees being exceptional. H. versicolor by greater range of color-change, the ability to live amid less moisture and more sunlight, shows a more perfect adaptation to tree life than H. pickeringii with less range of color-change and the need of more humidity. These frogs differ in time of appearance in the spring and disappearance in the autumn. They agree in the color and manner of distribution of the eggs, but with H. pickeringii the latter are smaller. So alike are the tadpoles in the earlier stages of their existence that at this period the mouth furnishes an important point for determining the identity. In these larval forms we again encounter a difference in mouth structure followed by a difference of habit in the adult frogs.

While this evidence may be insufficient to establish relationships, yet in determining the place occupied by the adult forms, these characters from the larval stages cannot be ignored.

Note. After the above paper was written, my attention was called to a paper entitled, "Sur les Caractères fournis par la Bouche des Têtards des Batraciens Anoures d'Europe." Par Héron-Royer et Ch. Van Bambeke. Extrait du Bulletin de la Société Zoologique de France. Séance du 26 Avril 1881. A comparison of some of the principal characters of the Hylidae, Ranidae and Bufonidae found in this locality, with those of the same families in Europe, results as follows:

"Lèvres externes et labre pectiné.—Tous les Ranidae et tous les Bufonidae possèdent un labre pectiné. Il manque chez les Hylidae." Here, all the Ranidae (excepting R. catesbeiana, which has frequently both papillae
and horny fringe or teeth at the edge of the upper lip), Bufo americanus, B. fowleri, Hyla versicolor and Hylodes pickeringii have a fringed upper lip.

Palatines.— "On en compte trois chez les Hylidae (Hyla arborea)." We count but one, separated by a gap above the upper jaw (Hyla versicolor and Hylodes pickeringii). "Chez les Ranidae, le nombre des palatines varie de 2 à 6. Toutes sont franchement latérales et très distantes de la ligne médiane." We count from 0 to 3 with the Ranidae. All are separated by a wide gap. "Enfin la présence de 2 palatines latérales seulement constitue un caractère distinctif de la famille des Bufonidae." We count in B. americanus and B. fowleri but one, separated by a gap above the upper jaw.

Linguales.— "Jamais une linguale médiane n'est située entre les linguales latérales et la mandibule inférieure." Here one sometimes finds an exception to this rule in the tadpoles of Hyla versicolor. In the other species it holds true. "Les Hylidae ont 4 linguales, dont 2 medianes et 2 latérales." Here, H. versicolor has 3 linguales; Hylodes pickeringii 2, with the edge of the lip usually partly fringed. "Chez les Ranidae, le nombre des linguales varie de 4 à 5. Chez toutes on compte 2 linguales latérales." Here, the number varies from 3 to 4 linguales. Only that next the lower mandible is separated, excepting occasionally in R. silvatica a partial division of the second fold occurs. "Pour le nombre et la disposition, les linguales des Bufonidae rappellent celle des Discoglosses; on en compte aussi de 3 à 4." Bufo americanus and B. fowleri have each 2 with a broad space of fringe of horny teeth at the edge of the border of the under lip.

**EXPLANATION OF PLATE 5.**

**Fig. 1.** Head of Rana catesbeiana in profile (2 diameters).

**Fig. 2.** Same enlarged 9 diameters; a. the upper lip; b. lower lip c. upper jaw; d. lower jaw; e. fringed fold; f. border of lip.

**Fig. 3.** Mouth of tadpole of Bufo americanus (10 diameters).

**Fig. 4.** Mouth of tadpole of Hyla versicolor (10 diameters).

**Fig. 5.** Mouth of tadpole of Hylodes pickeringii (10 diameters).

**Fig. 6.** Mouth of tadpole of Rana silvatica (10 diameters).

**Fig. 7.** Mouth of tadpole of R. catesbeiana (5 diameters).

**Fig. 8.** Mouth of tadpole of R. fontinalis (7 diameters).

**Fig. 9.** Mouth of tadpole of R. palustris (8 diameters).

Dr. M. E. Wadsworth said he desired to announce to the Society the discovery of picotite (chrome spinel) in the feldspar, augite, and groundmass of a basalt from Mt. Shasta, California.